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A METHODOLOGY FOR DETERMINING
THIRD WORLD SUBMARINE CAPABILITIES
CASE STUDY: IRAN

by

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September, 1992

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A Methodology for Determining
Third World Submarine Capabilities
Case Study: Iran

by

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ABSTRACT

This thesis presents a method to determine the capabilities of an emerging Third World submarine force. As a "primer," it examines the major factors that contribute to the operational readiness and military effectiveness of a submarine force. The areas discussed are national characteristics, research and development, equipment, training, and operations. The scope of the thesis is very broad in nature, and covers topics as varied as preventive maintenance, spare parts production, and crew training. The areas are analyzed with respect to their importance in estimating the submarine force's missions and capabilities. The penultimate chapter of the thesis uses the methodology to consider the significance of the Iranian acquisition of two *Kilo* submarines from Russia. The methodology is condensed (in the Appendix) to a checklist for use while evaluating an emerging submarine force.

TABLE OF CONTENTS

I. INTRODUCTION

This thesis provides a method for determining the potential of any submarine force. This paper is not designed to provide a comparison of the world's submarine forces, but rather to give a technique for ascertaining the capability of any given submarine force. John Benedict of Johns Hopkins Applied Physics Laboratory has done a significant amount of research in this area (Benedict, 1990, pp.57-63) and this thesis should complement his work by probing deeply into the essence of what makes an effective submarine force.

As the number of nations that possess submarines increases, and the number of submarines operated by these nations also increases, the capability to distinguish between a capable submarine force and an ineffective submarine force becomes more important but also more difficult. Simply adding up the number of submarines in each country gives little information as some submarines are permanently tied to piers or used for spare parts while other submarines are inadequately maintained to perform lengthy patrols. Comparing the number of submarines is also futile if the training, age, capabilities and missions are not included in the comparison. Two well-maintained submarines with proficient crews can be a much greater threat than twenty submarines that have not submerged in five years.

The thesis begins in Chapter II with a broad overview of the national aspects of the country in question. Starting with Mahan's elements of seapower, the state's position in relation to the sea should be analyzed along with the coastal tomography. The national leadership and characteristics of the population should be examined to determine the introspective perception of the purpose of the navy and the submarine force. The missions that are assigned to the submarine force should be correlated with the size of the force. The distance, routes, and types of seagoing trade should be considered and determined, as well as the political relationships with other nations.

The industrial and technological capacity of the state are discussed in Chapter III. These greatly influence the capabilities of the submarine force. These areas should be investigated to determine the research and development devoted to submarine related issues and the ability to produce submarines, their spare parts, and weapons. The proficiency in maintaining and repairing modern warships and the expertise in various specialized industries should also be considered to facilitate the evaluation.

Infrastructure to support the submarine force is discussed in Chapter IV. This is often an overlooked aspect of submarine capabilities, but the number and size of bases and the number of submarine tenders are important aspects in force readiness that should be weighed in the analysis.

Chapter V discusses the equipment that is used by the submarine force to add to its capabilities. A submarine crew with a modern weapons system is likely to achieve a hit on a slow moving merchant vessel if for no other reason than the high-technology, self-searching, self-homing torpedo. Better sensor systems enable the crew to detect targets farther away and position the submarine for an effective attack.

Training and operations are discussed in Chapter VI. These are absolutely vital to the readiness of the submarine force. The types of training evolutions and operations can also be good indicators of what a submarine force is capable of in terms of missions and roles. Consideration must be given to the success rate of the deployments and the problems encountered during the operation as well as the manner in which the problem was solved.

In Chapter VII, a brief analysis of the future Iranian submarine force is presented as an illustration of how this study's method may be applied. Inasmuch as this thesis is purposely unclassified, and the assessment is limited to information that is locally available, this chapter cannot be more than suggestive. A full application of the method would require, *inter alia*, very classified intelligence information, detailed open-source research data, and specific collection tasking on naval attaches, forces afloat, and so on. It is hoped, nevertheless, that an unclassified, limited open-source assessment of the world's newest submarine force

will encourage application of this method (using an all-source approach) on other potentially hostile submarine forces.

The final chapter is a summary of the results of the thesis.

II. NATIONAL ASPECTS

The position of a nation with respect to other nations and the surrounding waters must be considered when analyzing a submarine force. An island nation such as Japan might logically depend on its submarines to defend the country, while a nation with a very small coastline and land borders with threatening neighbors would probably place little emphasis on a submarine force. Mahan's elements of seapower (geographical position, physical conformation, extent of territory, number of population, national character, and character of the government) apply to a modern submarine force in much the same way as they applied to a turn-of-the-century navy (Mahan, 1991, pp.27-47). These aspects normally change very slowly over time, so they may be used as an initial basis for considering how committed a nation is to maintaining a submarine force and how adept that force could be expected to be in any operational environment.

A. GEOGRAPHY

Mahan espoused elaborate theories about a nation's geographical position in relation to other nations and the sea. He asserted that a nation having large coastlines, easy access to the sea, and no adjacent hostile nations is perfectly situated for developing an effective navy (Mahan, 1991, pp.27-47). Consider how some of Mahan's principles

mentioned above may be relevant to the development of a capable submarine force.

1. Island Nations

The factors discussed above work in favor of island nations like Australia, Cuba, Great Britain, Indonesia, Japan, and Taiwan, which rely upon the sea and sea commerce for their survival. Their navies strive to be capable of controlling the adjacent seas, suggesting the need for a proficient submarine force in order to preclude an invasion.

2. Sea-based Nations

Nations with long coastlines relative to their land boundaries historically depend more on the sea than do other nations. These littoral nations tend to look seaward for commerce. The larger the amount of seaborne cargo in relation to the country's needs, the greater the need of a navy to protect that commerce with proficient naval and submarine forces. Other nations with friendly land neighbors and large coastlines, such as Canada, Denmark, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and the United States, can also concentrate on building, maintaining and operating a submarine force.

3. Coastlines

Mahan considered ready access to the sea a noteworthy element of seapower (although he called it physical conformation). A measure of this access can be the length of the coastline, but a better measure would probably be the

length of the nation's territorial sea.[1] This measure gives a more realistic line which a navy needs to protect, because it eliminates the length of little inlets and bays. An example of the confusion using the coastline method shows South Korea with a coastline of 2,413 kilometers whereas the length of the South Korean territorial sea is only 1,100 kilometers.

4. Surrounding Waters

The geography of the coastal waters plays an important part in determining the capabilities of a submarine force. Nations with a significant amount of shallow water will likely have a submarine force that is adept at operations in these areas, but less capable at open ocean engagements. The small submarine (700 tons or less) is quite capable in shallow waters, while larger submarines require deeper waters. Even small submarines have their limits:

> Certain water depths must be considered limiting values for submarine operation. The following minimum water depths are considered to be acceptable for known submarine classes specially built for operations in shallow waters, with an average displacement of 500-1,000 m^3 [tons]:
> - 25 m for torpedo attacks,
> - 40 m for possible escape tactics afterwards
> - 18 m for mine-laying operations.(Boehm, 1989, pp.110-112)

A correlation can be done between a nation's submarine types and the tomography of the littoral waters. Nations with deep water close to shore may prefer larger submarines, whereas a nation with shallow waters out to a hundred miles presumably

[1] Territorial Sea: the area of ocean that is within twelve nautical miles of the baseline of the nation.

would be interested in smaller vessels. Notice should be taken if these characteristics do not correlate, i.e. a nation with a significant amount of shallow coastal water is acquiring large ocean-going submarines.

B. CHARACTERISTICS OF THE NATION

The national characteristics should be examined to aid in determining the objectives of acquiring a submarine force and the supposed missions that will be assigned to the submarines.

1. Leadership And Status

Every society may be analyzed for its leadership philosophies and attitudes. Democracies can be expected to have well-balanced military forces, with the navy sharing in the defense budgets in approximate proportion to its role in the actual defense of the country's national interest. Autocratic governments tend to favor armies useful for suppressing internal dissension as well as for intimidating adjacent nations.

A second dimension of national orientation is the desire for international status. The national status in relation to other nations as opposed to the status that it desires will presumably influence the readiness and effectiveness of the submarine force. If the nation acquired the submarines solely as a national status symbol, motivation to maintain a high operational readiness and force effectiveness may be weak. If the nation acquired submarines

or built them indigenously to counter a suspected threat, the navy is more likely to maintain the submarines in a state of higher readiness.

2. Characteristics of the Population

The people within a nation must be considered to assess how much support the submarine force will enjoy. Nations with a large sea-based population will likely admire and respect a submarine force, while those with little attachment to the sea will probably neglect a submarine force or if not despise it as a waste of resources. For example, the attitudes toward submarines displayed in the Soviet Union during the Cold War reflected ambiguities in national estimation of seapower.

3. Role of the Navy

The role of the navy in protecting national interests cannot be overemphasized, and submarine forces must be analyzed as elements of naval power. The size and composition of the entire navy must be reviewed. A navy comprised mainly of small patrol vessels may utilize its submarines for coastal defense -- or the submarines could be used for distant operations. Navies with larger ocean-going warships (destroyers and frigates) may be likely to employ their submarines in forward defense, while forces with cruisers and carriers could be anticipated to possess submarines for deep-water offensive missions. Clearly, the identity of putative enemies and assumptions about their

strategies influence a nation's naval planning, and this in turn would affect their operations.

4. Traditions

The role of the navy, and specifically the submarine force within a nation, can also be viewed from the traditions of the country. A country with a extended history of using the oceans will likely place more emphasis on its navy than countries new to the seafaring trades, and a country with a background in submarine operations will tend to honor and respect their submarine force. These traditions will also place the submarine force in high esteem with the civilians and could influence the more intelligent and braver men to apply for submarine service. This alone can be advantageous in promoting the readiness and improvement of a submarine force. The power of heritage is best expressed by Rudyard Kipling in *The Fringes Of The Fleet*:

> The submarine has created its own type of officer and man -- with language and traditions apart from the rest of the Service, and yet at heart unchangingly of the Service. (Heinl, 1966, p. 312)

The men and their attitudes are the intangible items that can change a submarine from an ineffective national showpiece into a highly lethal warfighting platform.

C. OVERSEAS INTERESTS

The distance and routes which foreign trade takes is also important to determining the probable requirements of a submarine force. These overseas interests have a direct bearing on the missions that the submarine force may be

called upon to perform. So too do foreign alliances and relations.

1. Distance and Trade Routes

The distance over which a country's imports must travel will affect the size, composition, and operations of its navy as will the routes that the goods must take in transit. The submarine force may be affected by those factors. To protect commerce in distant waters requires high endurance warships and long range submarines. Trade that must flow through chokepoints can be protected by smaller submarines. Distance and chokepoints are very applicable to Japan which imports 68% of its oil from the Middle East through the Straits of Malacca (*Basic Petroleum Data Book*, 1992, Section IX, Table 10i). This places the Japanese Navy in the extreme position of probably having to defend a very long oil supply line during any conflict that could threaten that supply line.

2. Nature of Trade

An appraisal should be conducted on the nature of the merchant shipping that flows into and out of a country. This appraisal should determine whether the trade is just commercially desirable, economically vital or required to sustain the life of the nation. Japan is an example of a nation that relies on shipping for its very survival because "Japan must import 50% of its requirement for other grains [not including rice] and fodder crops." (*World Factbook 1991*,

1991, p.160) The result of this analysis will lead to some conclusions as to the importance of the navy in general, and the submarine force in particular, in the protection of this shipping.

3. Foreign Relations

The relations that a country has with its neighbors or with other nations that share similar national interests will also help to set the context in which the submarine force can be evaluated. Alliances with distant countries will probably require long range warships just to conduct exercises with the allied navy. A treaty which discusses naval matters and allows one nation to concentrate on anti-surface missions while another devotes resources to the antisubmarine missions will give an idea as to the primary mission of each nation's submarine force.

A nation with surrounded by enemies will likely have a submarine force designed to protect its shores from the most likely enemy. The submarine force might be capable of conducting offensive operations against the supposed threat, but due to priorities it will probably not be trained to conduct missions in the far corners of the ocean.

III. INDUSTRIAL AND TECHNOLOGICAL CAPABILITIES

The ability of a nation to conduct research and development and actual production of a submarine and its systems is probably a dependable indicator for determining the capabilities of a submarine force.

A. RESEARCH AND DEVELOPMENT

A nation has many reasons for developing its defense research and development (R&D) capabilities, such as: to oppose hostile neighbors, to increase its own independence of action, to counter unreliable suppliers, to increase the economic and technological base within the country, to reap economic benefits by becoming a supplier of weapons systems, and to expand its political influence through arms exports (Catrina, 1990, pp. 11-21). Any nation developing a submarine force will be doing so for one or more of these reasons. For whatever reasons a nation develops its R&D capabilities, many benefits can be gained, including increasing the civilian technology base or increasing the population's standard of living.

1. Oceanographic

The exploration of the oceans is of primary importance to a submariner. This exploration can be limited to a country's coastal waters due to the limited scope of submarine operations, but at a minimum a country should

devote resources to explore the ocean areas in which its submarine force plans to operate to improve their operational effectiveness.

2. Weapons Systems

The initial stages of designing weapons requires many resources that most developing nations lack: money, technology, skilled personnel, and industrial capabilities. These and other limitations preclude most countries from being independent of the advanced nations which supply arms. Most nations rely on the highly developed states to perform the research and development of advanced weapons and then acquire rights to produce these weapons. The willingness of a country to engage in hostilities may be reduced if war would result in diminished access to modern weapon systems.

B. INDIGENOUS PRODUCTION AND IMPORTS

Whether discussing entire submarines, spare parts, or weapons, the costs and benefits in resources, manpower, and infrastructure of indigenous production must be weighed against the disadvantages of importing.

1. Submarine Production

The building of submarines is a highly complex task requiring a wide variety of skills and technologies. This is exemplified by the fact that only eighteen countries have produced submarines; two of these (Spain and Denmark) have not produced submarines in the last five years, and six of them have only recently become submarine producers -- all

building foreign-designed boats (*Jane's Fighting Ships, 1992-93*). The ability to produce submarines within a nation not only gives that nation a secure supply in a long-term conflict (presuming access to critical raw materials), but also provides the country with an inventory of qualified repair personnel for maintaining a submarine force. More and more nations are acquiring the skills to build submarines as they realize the importance of being able to complete the construction process indigenously. In developing the *Collins* Class submarine, Australia has adopted as a primary objective the goal of minimizing foreign suppliers because the Australian government and Royal Australian Navy (RAN) feel that the "deterrent value in the region will be enhanced" if the submarines can be built and maintained in Australia (Young, 1991, pp.42-55).

A nation can also be quite capable of building a submarine by having the metal and machinery stocks, a pool of skilled labor, and the dockyards to produce the warships, yet be unable to build a submarine due to the unavailability of weapons and sensor systems. Reverse engineering these components after acquisition of a submarine is a possibility. Many developing nations could probably follow this path.(Slade, 1991, p.32)

2. Spare Parts

There are two important aspects when considering spare parts: place of production and stockpiles. Any naval

ship requires spare parts, and a submarine's requirements often exceed those of its surface ship counterparts. Thus, while a surface ship can go to sea with questionable ship control systems, it is absolutely vital that the same systems be fully operational on a submarine. A loss of propulsion to a surface ship will require that the ship be towed to port, but a corresponding loss of propulsion to a submarine could place the submarine in an unrecoverable depth excursion which would destroy the submarine and kill its crew. Therefore, a submarine must have readily available supplies of spare parts to keep vital ship systems fully functional. A foreign supplier entails that availability of components could be limited or nonexistent during a conflict unless stockpiling were done prior to the conflict. Even if some stockpiling were conducted, the supplies could run short during an extended conflict or embargo. The Argentine experience during the conflict over the Falklands is a perfect example of how this shortage can hinder submarine operations. The U.S. had placed an arms embargo on Argentina in 1976, and by 1982 the embargo had "severely hampered" the "Argentine efforts to keep these boats [U.S. GUPPY Fleet submarine] operational."(Sheina, 1984, pp.114-120) The preferable source for vital spare parts is an indigenous producer. This would give the nation unlimited access to those spare parts and allow the submarine force to operate without restrictions caused by shortages of maintenance components. In times of

crisis, indigenous production would in theory provide a supply unhindered by any economic embargo or blockade.

3. Weapons Production

Similarly, the nation that truly desires to be free of outside interference must have freedom from arms suppliers. Producing submarine torpedoes requires a well-developed technology base even if done under license from another country that performs the design and development. Currently only ten nations are producing torpedoes: China, France, Germany, India, Italy, Japan, Russia, Sweden, the U.K., and the U.S. (Friedman, 1989, pp. 416-433). Stockpiling of weapons will allow non-producing nations to overcome this dilemma in short crisis situations; but the ability of a submarine force to wage war for extended periods of time will be hampered if the nation cannot produce its own torpedoes.

C. MAINTENANCE AND REPAIR

Any nation with a submarine force needs adequate repair facilities to ensure the continued operational readiness of its. The repair facilities should be extensive in nature in order to return even badly-damaged ships to operational status.

1. Number of Maintenance Facilities

Because there are severe limits on a submarine force with only one operational base, a nation serious about using a submarine force in a wartime environment generally will

need more than one harbor capable of operating and repairing the submarines. They can be kept in port by only a limited number of ASW ships in blockade. And if the submarines are at sea at the beginning of a crisis, their covertness eventually is compromised by having to proceed to and from one particular port. The limits imposed on a submarine force by having only one operational base are clearly restrictive and will cripple the force if damage occurs to the base during a war or natural catastrophe.

The strategic advantage of multiple ports has been proven throughout naval history. The most recent example would be the British having to split up their 1982 Falklands War assets to watch all the Argentine naval ports; this allowed the *San Luis* to exit and enter port and operate relatively unhindered throughout the operations area (Sheina, 1984, pp.114-120). Although the perceived threat was surface-based in nature (the cruiser *Belgrano* and the carrier *Veintecinco de Mayo*) (Woodward, 1992, pp. 123-124), the British nuclear attack submarines (SSNs) are some of the best in the area of Anti-Submarine Warfare (ASW). If a diesel submarine can slip by the Royal Navy, other nations are likely to attempt to use their submarines in wartime if the port facilities are available. Multiple submarine bases magnify the ASW problem of an enemy and can compel an enemy to split his forces.

2. Major Repairs and Overhauls: Indigenous vs Foreign

As described above for the repair facilities, the number and location of drydocks capable of supporting a submarine overhaul also will help determine the capability of the submarine force. Having to send submarines to a foreign country for an overhaul or hull cleaning implies that the nation is unable to support the submarine force for an extended period of time and unwilling to commit the resources to make its submarine force a high priority. The company that produced the submarine is likely to have the facilities to perform major maintenance and, like HDW (builders of the *Type 209*), are more than willing to effect this maintenance (Ude, 1986, p.3). Sending of submarines to an overseas shipyard implies that the *submarines are for short duration* conflicts or show the flag type missions.

3. Routine Maintenance

The performance of a submarine force is highly dependent on the quality and quantity of routine maintenance. Routine maintenance includes preventative maintenance, corrosion protection, and periodic equipment tests. All of these items can help to increase the effectiveness of a submarine force. The quality of routine maintenance should take into account the attitude of the personnel. The amount of preventative maintenance can probably be estimated by the activity around a submarine while it is in port. Corrosion protection can be evaluated by the amount of rust seen on the

surface of the submarine or -- perhaps -- correlated to the quantity of corrosion that is evident on the surface ships within the Navy. The abundance of equipment tests might be approximated by observing the types and quantity of non-crew personnel that board the submarine, including technicians from foreign country. Any other ways to determine the caliber and amount of routine maintenance will help to weigh the effectiveness of a submarine force.

D. SPECIALIZED INDUSTRIES

Many industries are involved in supporting a submarine force, but several are vital. These industries can be crucial to the readiness of the submarines, and every effort should be made to determine the capabilities of the nation in each area.

1. Optics

The need for periscopes on submarines became apparent from the very beginning of submarines. Today most periscopes have become multipurpose tools with many features that enhance the submarine's ability to detect, locate, classify, and attack an opponent. The nucleus of the periscope is the optics which allow the submariner to see. Non-Russian producers of periscopes include Carl Zeiss (Germany), Kollmorgen (U.S.), Barr & Stroud (U.K.), Sagem and Sopelem (both in France) ("Above Water Sensors," 1986, p. 57). The small number of companies that produce and repair periscopes is *prima facie* evidence that periscopes are costly and

sophisticated. Any indication that a nation is developing a high technology optics industry could imply that it is trying to become independent in this area of submarine maintenance.

2. Welding

The construction and repair of modern submarines requires an proficiency with advanced welding techniques for thick hull plating. The pressures to which the submarine can be subjected at deep depths are extreme (3.07 MPa or 445 lbs per square inch at 1000 feet), and simple welding techniques do not hold out the sea water. Sea water piping is subjected to the same pressures as the hull and require the same welding techniques. A country must be prepared to send its submarines to a foreign port for any sea water piping or hull repair if there is not an indigenous capability to perform this type of work. Obviously a submarine-producing nation has this capability, but the countries that do not produce submarines should be watched closely for any indications that high technology welding skills are being developed.

3. Electronics

There are several systems on submarines require electronics: Navigation, Sonar, Electronic Support Measures (ESM), Fire Control, and Communications. While all of these functions can be performed without the aid of electronics, most submarines incorporate modern circuitry to perform some or all of these functions. Despite the fact that most of these systems are well designed with low failure rates, a

nation must be capable of repairing such mission-critical items quickly in order to allow their submarines to operate unrestricted by equipment limitations. A nation with a limited ability to repair electronics will possibly have a reduced submarine operational capability unless there are indications that the submarine force is given priority for the resources and technical repair capabilities of the country.

4. Batteries

The foremost method that should be used to evaluate the submerged endurance of a submarine is the battery capacity. More generally, the better the battery system (in reliability, storage capacity, and recharging rate), the more capable the submarine is of conducting demanding tasks such as a submerged ASUW approach or an ASW barrier patrol mission.

a. Maintenance

The skills and technologies required to maintain a modern submarine battery involve a significant amount of training and practical experience. These skills are not beyond most developing countries, but the amount of training devoted to battery maintenance is often considered crucial when determining the capabilities of a submarine force. For example the battery in the *TR1700* has 960 Varta battery cells, which makes for a very complex and management-critical maintenance schedule (Dicker, 1983, p. 1293).

b. *Production*

The production of submarine batteries is a task of such complexity that many countries must rely upon a foreign manufacturer. The limits imposed on a diesel submarine by an old or damaged battery places production of submarine batteries at the forefront of any submarine force's requirements. There are five major suppliers of submarine batteries (SAFT in France, Varta in Germany, Hagen in Germany, Tudor in Sweden, and Chlorides in the U.K.) that will produce batteries of all sizes and shapes to meet the need of any submarine force ("Propulsion," 1986, pp. 50-51). These companies engage in intensive research and development to improve their product; and these companies, like Hagen Batterie AG of Germany, are willing to co-produce or grant production licenses to other countries (Hagen has sold these rights to five nations -- Israel, Norway, Turkey, South Korea, and India) (Hagen Batterie AG, 1991, p.1).

5. Advanced Technologies

There are several areas of advanced technologies which should be taken into account when determining a submarine's capabilities. Current trends in submarine technology are to increase the submerged endurance of the submarine through a variety of air-independent propulsion (AIP) systems. These AIP systems allow a submarine to stay submerged longer, thus increasing its stealth and decreasing

its indiscretion rate.[2] AIP technologies currently being investigated include the use of Stirling engines, fuel cells, closed-cycle diesels, and innovative waste gas storage (i.e. torrodial hulls) (Benedict, 1992). An indication of research in any of these technologies would tend to indicate that a nation is developing advanced capabilities for its submarines which could greatly increase their submarine's potential.

6. Sound Silencing Technology

The use of technology in design and manufacture to reduce sound in submarines has three major facets; namely propellers, sound mounts, and propulsion equipment. All three of these areas require high technology development systems, sophisticated production machinery, and conscientious maintenance procedures. The ability to make quiet and efficient propellers is beyond the expertise of most developing nations, but that need not keep countries from importing the technology, milling equipment, and materials to attempt such a feat. Propulsion equipment such as reduction gears, electric motors, and bearings are within the production abilities of most developing countries, to produce, but the fabricating of quiet specimens requires more precise manufacturing facilities and technological refinement than such countries have the skills to perform. Effective

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[2] Indiscretion Rate (IR) for a given speed is defined as:

$$IR = \frac{\text{Time required to return the battery to full charge by snorkeling}}{\text{Time required to discharge the battery to some minimum level}}$$

sound mounts require not only a production infrastructure, but also the electronic processing equipment to determine the ability of the mount actually to isolate the vibrations from foundation of the equipment.

IV. INFRASTRUCTURE

Infrastructure of the submarine force includes bases, pier space, tender support, drydocks, and maintenance facilities. Maintenance was discussed in an earlier section; the following sections present the first four items.

A. SUBMARINE BASES

The number of bases, amount of pier space, size and number of submarine tenders, and the availability of drydocks are important aspects of a submarine force's infrastructure that will help to determine the capabilities and limitations of the individual submarines.

1. Number of Bases

To a submarine force composed of large ocean-going submarines, the number of bases is vital to the sustainment of the operational submarines. Large submarines (greater than 1700 tons) have drafts greater than five meters and need logistical support normally not available at civilian ports. While smaller submarines can get diesel fuel in any fishing port and restock their consumable supplies from a corner grocery store, taking on more weapons normally requires dedicated support from land-based infrastructure (although as discussed below, this operation can be supported by a submarine tender). The number of bases must be considered in relation to the size of the submarines, and any use of non-

military ports by submarines should be noted, because this adds flexibility to the force in a crisis.

2. Pier space

The amount of pier space is tied almost directly to the number of submarine bases, but in addition the submarines can be supported at any naval base. A nation with several small submarine bases would have a greater warfighting capability if each base could individually maintain the entire submarine force. This of course is an ideal which cannot always be realized, but the more flexible the infrastructure, the more capable the submarine force.

3. Tender Support

One aspect often overlooked when examining the capabilities of a naval force is the afloat support structure. For a submarine force, a tender is almost vital for wartime operations. A tender provides a submarine force with the capability to deploy without the constraints of having to return to a base for fuel, weapons, or supplies. The tender also allows a submarine to be repaired while away from the nation. Moreover, an illusion of having a submarine at sea threatening another nation might be maintained when in actuality the submarine is being serviced in an obscure location; a tender becomes a "capabilities multiplier" for any submarine force. When the French Navy sends a diesel submarine to the Indian Ocean, a tender travels to the ports that will be visited "to preserve the know-how in

implementing the logistical support indispensable for full submarine availability."(Fustier, 1989, pp. 32-36)

4. Drydocks

The number of drydocks that can hold a submarine is an indirect method for determining the abilities of a submarine force. The extreme case -- a country without a suitable drydock -- cannot conduct extensive repairs on damaged submarines, nor is the country able to perform extensive maintenance procedures on the hulls of the submarines.

5. Training Facilities

The extensiveness of the training facilities should be examined. The number of buildings is a basic consideration, but the types of simulators and training aids are also important. This topic is discussed in more detail in the section on training.

V. EQUIPMENT

The submarines themselves are valuable indicators for determining the capabilities of the force, but particularly the weapons systems, sensors, navigation systems, and fire control systems must be considered. These systems change the submarine from a simple submersible to a warfighting platform.

A. SUBMARINE

The basic cornerstone of any submarine force must be the submarines themselves. The capabilities of each type of submarine must be thoroughly evaluated using all the information that can be gathered through any channels. The smallest morsel of information may be remarkably important in helping to determine what missions the submarine force is capable of executing successfully.

1. Size of the Submarine

The first look at any submarine force should be the size of the submarines that are operational. As will be shown later, simple measurements like length, beam, and displacement can be used to determine many aspects of the submarine's performance. In general, submarines can be divided into three groups based on displacement: small (less than 700 tons), medium (700-1700 tons.), and large (greater than 1700 tons).

a. Small Submarines (less than 700 tons)

The small submarines are ideally suited for coastal operations of limited duration. These submarines (usually less than fifty meters in length) can maneuver into places where larger submarines are incapable of operating. In addition, the small submarines have shallower drafts (less than five meters) which allow them to go into harbors with depths that would thwart the larger submarines. The smaller submarines also have fewer personnel (eighteen to twenty-two men) and smaller consumable loadouts, thus enabling them to be resupplied and refueled in any port capable of handling a fishing vessel of nominal size. These advantages are offset by a number of disadvantages: very poor seakeeping in non-coastal waters, limited endurance in both fuel and personnel supplies, a minimum weapons load (six to eight torpedoes), and slow submerged speeds (less than eighteen knots).

b. Medium Submarines (700 to 700 tons)

These submarines are particularly suited to forward defense. They are a compromise between the long-range, ocean-going large submarines and the short-range, shallow-water small submarines and are well suited for local operations in littoral waters. The medium submarines have a longer range and patrol endurance than their smaller counterparts, but still do not have the size necessary to be effective blue-water, warfighting platforms (although open-ocean commerce raiding is well within the capabilities of a

medium-size submarine). In comparison to the small submarines, medium size submarines have a larger weapons loadout (twelve to sixteen torpedoes) and higher submerged speeds (eighteen to twenty-three knots). The larger crews (generally twenty-two to thirty-two men) and longer patrol endurances mean that a larger quantity of consumables must be carried. The lengths of medium size submarines (roughly forty-eight to sixty-five meters) gives them improved sea-keeping ability, but do not give the medium submarines extended blue-water capabilities due to poor performance in rough weather.

c. Large Submarines (greater than 1700 tons)

Today's large submarines are the heirs of the World War Two "*Gato/Balao*" Fleet-class submarines built by the United States. These submarines are usually long (more than sixty meters), and with the added weight and size, and are very effective for blue-water operations. Their larger diameters (exceeding six-and-a-half meters) also add to open ocean capabilities, but limit their operations in shallow water. The older submarines have larger crews (greater than fifty men), but the newer submarines are incorporating high technology automation allowing them to have crews as small as the medium size submarines. The larger weapon loadouts (fourteen to twenty-four torpedoes) and more space for consumables allow longer wartime patrols without having to return to port for resupply and rearming. The large

submarines also carry more fuel and are capable of routinely crossing the oceans. Unfortunately, the larger size does not improve the speed capabilities when compared to the medium submarines, but most of the large submarines have increased battery sizes that give them longer submerged endurance for a given speed.

2. Age

Newer submarines are usually more capable fighting ships, but older submarines should be given the benefit of the doubt. Conventional submarines have not fundamentally changed since World War Two and surface ships are still ineffective at finding a submarine and incapable of defeating the torpedo. The German 1944 *Type XXI* is very similar to the 1980s-era *Type 209 (1500)* [as shown by the Table 1], with the major changes

TABLE 1: COMPARISON OF WORLD WAR TWO AND MODERN SUBMARINES

	TYPE XXI	*TYPE 209 (1500)*
Surf/Subm Displc. (tons)	1621 / 1819	1660 / 1850
Length/Beam (m/m)	76.7 / 8.0	64.4 / 6.5
Surf/Subm Speed (knots)	15.5 / 17.5	11 / 22
Submerged Horsepower	4,800	4,600
Surf Range/Speed (nm/kts)	15,500 / 10	13000 / 10
Subm Range/Speed (nm/kts)	365 / 5	400 / 4 (est)
Torpedo Tubes/size (#/mm)	6 / 533	8 / 533
No. of Crew	57	40
Refs: *Jane's Fighting Ships, 1992-93* and *Submarines of World War Two*		

being the reduced crew due to automation and the smaller size due to submerged streamlining. Their similarities are astounding and the older submarines can perform most of the missions with much the same effectiveness. The one mission area which has progressed beyond the older submarine's capabilities is ASW. Finding a modern quiet submarine and hitting it with a torpedo are probably beyond the abilities of pre-1960s submarines.

3. Technology

The 1991 Persian Gulf conflict has shown that high technology weapons are operationally powerful and remarkably accurate. Although unproven in that conflict, technology in submarine warfare is also important. The ability of a submarine to *find and destroy a warship* can require sophisticated hardware, especially in a large open-ocean scenario. Surface warships are quieter, with long range ASW sensors quite capable of detecting a noisy submarine and long range weapons that can easily destroy an unsuspecting submarine. To provide for self-protection and offensive capabilities, a modern submarine employing high technology sound silencing, sensors, and weapons stands a better chance of conducting a successful mission. But, while technology is important, it should not be overemphasized, as it may also be a drawback in some respects. For example, during the 1982 Falklands War, the Argentine submarines could not fire their sophisticated SUT-4 torpedoes due to inoperable fire control

systems an inability to effectively use wire-guided torpedoes (Sheina, 1984, pp.114-120). Mistrust of the high-technology Tigerfish torpedo may have been what led the commander of the British submarine *Conqueror* to use antiquated World War Two Mk 8 torpedoes to sink the Argentine cruiser *Belgrano*.

4. Capabilities

The capabilities discussed in this section are those that are built into the submarine and cannot be changed without an extensive overhaul.

a. Patrol Endurance

Several variables that must be considered when determining a submarine's patrol endurance are fuel capacity and usage rates, and consumable storage capacity versus crew size. Fuel capacity and usage rates more appropriately come under the heading of range and will be discussed in that paragraph. Consumable storage must be compared to the crew size. A large modern submarine with significant automation will require fewer crew members and will more likely have a longer patrol endurance due to more space for consumables. The amount of consumable storage will probably be imprecise since prior to an actual combat patrol a submarine can always carry more food by stacking cans in the passageways and other places not normally reserved for food storage.

b. Submerged Endurance

This is a very sensitive subject since most nations consider this information highly classified. The

submerged endurance of any diesel submarine is based on three major parameters: battery energy capacity, size of the submarine, and speed. Several publications have developed formulas which can be used to correlate speed and the size of the submarine. The best method to use appears to be that presented in *Strategic Antisubmarine Warfare and Naval Strategy* (Stefanick, 1987, pp.142-143):

$$V=K_1\left(\frac{P_s}{LB}\right)^{\frac{1}{3}}$$

This formula relates the length (L:feet), the beam (B:feet), and the shaft horsepower (P_s) to the maximum submerged speed (V:knots) of a submarine. The coefficient K_1 is approximately 25 for modern single-propeller submarines. Another useful formula is presented in *Submarine Construction* (Gabler, 1972, pp.42-43):

$$V=K_2\left(\frac{P_s}{D^{\frac{2}{3}}}\right)^{\frac{1}{3}}$$

It associates the displacement (D:meters[3]) and shaft horsepower to the velocity with the constant K_2 being approximately equal to 6.91 for a modern diesel-electric submarine. Using empirical data on current classes of submarines listed in *Jane's Fighting Ships* , it can be shown

that these two equations are closely associated with a correlation coefficient of 0.871.

The last aspect that needs to be integrated is the battery energy capacity. Using data supplied by Hagen Batterie of Germany, an estimate of the approximate power output of a battery may be obtained by the equation (Hagen, 1992, p. 14):

$$P_e = M * K_3 * T^C$$

This equation relates the time on the battery (T:hours) and the mass of the battery (M:tons) to the power output for the battery (P_e:kilowatts) using two constants, K_3 equal to 21 and C equal to -0.865. Either of the first two equations can be used in connection with the third equation (including a factor for power conversion and propulsion efficiency) to give an indication of the endurance of a submarine operating on the battery.

c. Range

The range of a submarine depends on the speed and the fuel capacity. For a given amount of fuel, the equations presented above are perfectly valid for a submerged submarine using a snorkel. For submarines cruising on the surface, normal surface ship fuel consumption versus speed equations can be applied. These calculations should be done to determine the approximate range of a given type of submarine. Small nations with short coastlines will probably not need

the longer range inherent in larger submarines. But close attention should be given to a nation which acquires long range submarines because they can be sent to any area of ocean.

d. Open-Ocean Potential

Large submarines have better sea-going capabilities, but the nation may not need blue-water submarines. The open-ocean potential of a submarine force must be examined first from the aspect of the size of the submarines and then from the training that the submariners receive.

e. Speed

High speed submarines are nice to have, but are not necessary for local operations. Most of the smaller submarines have speeds which are adequate for performing any assigned mission. The higher speed submarines are well suited to perform open-ocean missions, whereas a nation with low speed submarines can probably be evaluated as intending them for coastal defense. It should be noted that in shallow waters, maneuverability and size are more important than speed. The acoustical advantage of a submarine operating in shallow seas more than offsets the reduced speed capabilities of a smaller submarine. In shallow waters a submarine's primary means of escape is not speed. Notice should be taken of a nation which has declared coastal protection a primary concern but actually has high speed submarines.

5. What Missions can the submarine perform?

The missions which a submarine can perform are varied and complex in nature. Some require a significant amount of training and expertise and a sophisticated submarine, while others can be accomplished successfully with little training and an obsolete platform.

a. *ASW*

The ability of a diesel-electric submarine to conduct antisubmarine warfare (ASW) is extremely limited due to the restrictions placed on processing power by the electric power available from the battery. To detect and attack a modern submarine requires sensitive sensors and powerful processing systems which would quickly drain a conventional submarine's batteries. Although some diesel submarines carry ASW weapons, these can be considered to be available for self defense only.

b. *ASUW*

A submarine is a superb anti-surface warfare (ASUW) platform due to its inherent stealth and destructive weapons system. An evaluation needs to be conducted to rate the ability of a nation's submarines to detect surface ships using their sonar systems. Modern submarines should be able to detect surface ships out to one convergence zone in deep water. In shallow water, the submarine's sonar system provides a slightly better detection performance than being on the surface and searching visually. The two limiting

factors for a submarine in ASUW are submerged approach speed and the weapons capabilities. Both of these are discussed in their respective sections.

c. Special Operations

Most diesel-electric submarines are perfectly suited for conducting special operations due to their small size and stealth. The determining factors for special operations are simply the number and size of the "lock-in/lock-out" systems and the space available for extra personnel, i.e. divers/frogmen/scouts. These two aspects must be evaluated for each class of submarine to determine its capabilities for conducting special operations.

d. Mining

Diesel-electric submarines are also well suited for mining operations. Depending on the design of the submarine, mines can be carried internally (two mines take the same amount of storage as one torpedo) or externally in a minebelt that can hold several dozen mines. While this mission is often overlooked due to the limited number of mines that a submarine can carry, it should be remembered that in World War Two 658 mines were deployed by the Allied submarines in the Pacific which caused fifty-two Japanese ships to be damaged or sunk; that represents a ratio of 12 mines for each ship damaged (Moore, 1987, p.25). In addition, German mines planted off the coast of the United States caused several ports to be shut on just the threat of

mines. But this function should be evaluated for each submarine that a nation possesses to help determine the overall capabilities of the submarine force.

e. Surveillance/Reconnaissance/Electronic Warfare

The ability to conduct reconnaissance of a beach or surveillance of a harbor is also a suitable mission for a diesel-electric submarine. The surveillance/reconnaissance mission requires few capabilities and generally could be performed by an obsolete submarine. The electronic warfare mission requires more modern technology and more space for the detection and processing equipment. If either one of these requirements is not met, the ability of the submarine to effectively conduct an electronic warfare mission is hampered.

f. Strike

Attacks on shore targets is a relatively new major mission for submarines. Prior to the 1960s, most submarines had : guns to perform limited strike missions, but during the middle years of the Cold War this mission disappeared. With the advent of the submarine-launched land-attack missile, the strike mission has been reassigned to the submarine force. Only the United States and Russia have the weapons systems and submarines to perform strike missions; but careful attention needs to be given to other nations in order to detect any signs that this capability is being attained.

g. Search and Rescue

To perform search and rescue (SAR), a submarine does not even need to submerge. This alone makes the search and rescue mission an easy one. Obviously, however, the stealth of a submerged submarine greatly enhances the ability of the ship to perform a SAR mission, especially in a hostile area of the ocean. Yet even this category of the SAR mission requires very limited capabilities in a submarine.

6. How many is enough?

The number of submarines that are adequate depends on the missions that the submarine force will be called upon to perform. Can a nation with two submarines offer a credible threat? Conventional wisdom says that a two submarine force is too small to maintain an acceptable influx of submarine personnel or submarine readiness. Thus, the French government believes that to have an effective force "two submarines must be ready at all times to put to sea." To meet this requirement the French Navy concludes that a minimum of four submarines "guarantees at least two fully operational submarines at all times" and also provides "a satisfactory flow of submarine personnel" and "allows the submarine maintenance yards to be organized and managed effectively." ("Creating A Submarine Force The French Way," 1989, p. 46)

Looking from another aspect, the number of submarines required depends on the missions which will be assigned to

the submarine force and the area of operations. Given the current levels of submarine forces and an assumed eighty mile ocean boundary around each nation, the average ocean area per submarine is 160,000 square miles (200 x 80). This area is also significant, because a diesel submarine searching at 4 knots with a detection range of twenty miles can cover this area in approximately 100 hours of submerged operation (Koopman, 1946, pp.95-107). This coincides with the submerged endurance of many modern submarines. Logically this leads to the supposition that any submarine force that has more than one submarine for every two hundred miles of territorial sea perimeter could be presumed to be offensive in nature.

A basic measure for helping to determine the capabilities of a submarine force is the size of the force. The variety of missions that can be performed effectively depends to some degree on whether a nation has a small force (three or fewer submarines), a medium force (four to seven submarines) or a large force (at least eight submarines).

a. *Small Submarine Force (up to three submarines)*

A small force of only two or three submarines is limited in the operations that can be performed effectively. As ASUW platforms, three submarines will be ineffective as commerce raiders against a large merchant fleet. These submarines, due to a limited quantity of weapons and possible destruction from escorts, would be effective only in a

terrorist manner. The actual threat to commerce for an extended period of time would be restricted in numbers and area.

On the other hand, a small submarine force can effectively frustrate an amphibious operation by inflicting enough damage on an enemy task force to cause a withdrawal or subsequent defeat on the ground. Against warships engaged in a blockade or sustained strike operations, a small submarine force could present a threat, but would not likely cause a proficient navy to be completely deterred from carrying out operations in the submarine's area. The British were worried about the possibility of an attack from an Argentinean submarine in the Falklands conflict; but the British task force commander felt that the threat would be limited to the inshore shallow waters as coastal defense platforms (Woodward, 1992, p.123). Special operations and reconnaissance are well within the scope of a small submarine force; but extensive mining and large area ASW are not missions that a small submarine force can perform with a great degree of success. "Declaratory mining" or terrorist minelaying also can be accomplished by one or two submarines, with little risk in most cases.

b. Medium Submarine Force (four to seven submarines)

A submarine force composed of from four to seven submarines can perform almost any mission with the possible exceptions of full-scale commerce raiding and sea denial

against a strong navy. A medium submarine force can be used in limited commerce raiding, as an effective deterrent to an amphibious force, and as competent weapons against surface warships. Throughout this century of submarine warfare, there has not been an instance of a small or medium submarine force effectively controlling an area of ocean. Although a medium submarine force can be proficient at ASW, it is more likely to be geared toward other missions. As will be discussed later, four submarines is considered the minimum for an effective fighting force, although even a single submarine must be regarded as a lethal threat.

c. *Large Submarine Force (eight or more submarines)*

The larger submarine forces are more likely to be proficient in all areas of submarine operations. The larger numbers imply a greater commitment to an effective force and also suggest that the submarines will not be overlooked in training, exercises, and operations. Surprisingly, sixteen nations (37% of nations with submarine forces) have large submarine forces: China, France, Germany, Greece, India, Italy, Japan, North Korea, Norway, Peru, Russia, Sweden, Spain, Turkey, the U.K., and the U.S. Most of these forces probably have the capability to conduct sustained combat operations and are likely to be proficient in all areas of submarine operations. All except Greece, Norway, and Peru are building or have built submarines, and all of the nations could presumably produce them again in a war or crisis.

Germany began World War One with twenty-four submarines of modest capabilities but nearly won the Battle for the Atlantic by having the capability to build more (340 more during the course of the war) (Lindsay, 1980, pp.32-41). The production of submarines is probably needed to sustain a highly effective and capable submarine force, particularly in wartime or during a lengthy confrontation.

7. Weapon Storage

The versatility of a submarine can be estimated by the number of weapons that the submarine can store for a deployment. Some of the earlier *Type 209s* could store torpedoes only in the tubes (six or eight), while the larger modern submarines can carry twenty or more in the torpedo room. The weapons storage capabilities can be gauged from the external dimensions of the submarine and the method of loading the torpedoes. The larger submarines usually hold more weapons and the submarines that require loading through the front of the torpedo tubes typically are limited in weapons to the number of tubes.

Almost any submarine can be equipped with a minebelt. The minebelts being produced and exported can be attached with relative ease to a submarine and can provide any nation with a great increase in the capabilities of their submarines. These minebelts are usually close to neutral in buoyancy so as not to upset the operation of the submarine and they can be jettisoned from inside the submarine in an

emergency. ("UDT '92 Conference & Exhibition Preview," 1992, p. 42)

8. Weapons Launching Systems

While the determination of how a submarine launches a weapon may not seem important, it actually can tell many things of interest to a naval officer. A submarine that can impulse[3] a weapon is less limited in its operations because the submarine can be going at any speed and maneuvering while still being able to launch its weapon. Also, due to a lack of propulsion for the underwater missile system, all current missiles require some sort of impulse system to force the missile out of the tube. A disadvantage of the impulse system is the amount of noise that is created when the weapon is launched.

A launch system that requires swimout weapons is just the opposite in almost all respects. It is a stealthy way to launch a weapon, but usually imposes restrictions on speed and maneuverability on the submarine. The sophistication and maintenance standards of a swimout launch system are usually less than for the impulse system, and the internal space requirements are significantly less for the swimout system.

9. Surface-to-Air Missile (SAM) Launchers

Since naval guns were removed from submarines, the submarine has been unable to counter its worst adversary, an antisubmarine aircraft. This shortcoming could be rectified

[3] impulse: using high pressure air or water ram to force a torpedo or missile out of the torpedo tube.

by the installation of a surface-to-air missile launcher. The likely location of the launcher would be in the conning tower and therefore a close inspection of the top of the sail might in the uture be required to verify that a particular submarine has a SAM launcher installed.

B. WEAPONS SYSTEMS

After the capabilities of the submarines have been evaluated, a survey of the weapons that the submarines can employ must be done.

1. Torpedoes

The torpedo remains the premier weapon of the submarine force due to its stealth, destructive power, and immunity to defensive measures. A submarine crew can be totally incompetent, and yet as Winston Churchill stated in a memorandum for the First Sea Lord, 21 October 1939:

> It may well be a hundred to one against a hit with a heavy torpedo upon a ship, but the chance is always there, and the disproportion is grievous. Like a hero being stung by a malarious mosquito.(Heinl, 1966, p. 326)

Due to this damage potential, the characteristics of each type of torpedo need to be collected and the capabilities then need to be resolved. There is a wide variety of torpedoes available to a submarine force ranging from the large heavyweight impulse torpedoes (e.g., Mk 48, Mk 24 *Tigerfish*, and Type 53) that are usually faster high performance weapons to the smaller, slower, swim-out torpedoes (e.g., Mk 37, *Stingray*, Whitehead A244). Each torpedo can have a specific application (ASUW or ASW) or it

can be multipurpose. The torpedo could be unguide or it can have an active or passive homing system. The torpedo guidance could allow it to be wire-guided, autonomous, straight-running, or a combination of any of these. The warhead can be a small shaped-charged designed for double hull penetration, a large high explosive charge designed to break the keel of a ship, or even a nuclear weapon to destroy a battlegroup or a coastal city. Each of these torpedo characteristics needs to be determined, and even a small amount of information will allow some or all the aspects to be judged.(Friedman, 1989, pp.416-433)

2. Missiles

Only ten nations (China, France, Greece, Israel, Japan, Netherlands, Russia, Pakistan, the U.K., and the U.S.) currently have submarine launched missiles of which seven of those use U.S.-produced HARPOONs (*Jane's Fighting Ships, 1992-93*). Although many other nations would like to acquire this capability, the technology needed is probably beyond the reach of most developing nations. Any missile system installed onboard a submarine must be evaluated to determine whether it is anti-ship, antisubmarine, or land attack and whether the submarine has to surface to fire the missile or if the submarine can launch the missile while submerged. From the dimensions of the missile, range and explosive power can be estimated. Data pertaining to the accuracy of the missile would also be extremely important. Any indication of

a nation acquiring or developing this technology would be a vital piece of information, because to date only four nations have actually developed submarine launched missiles: China, France, Russia, and the U.S. (with the Chinese missiles requiring the submarine to be surfaced).

3. Mines

Many types of mines are available to a submarine force and there are several methods of deploying these mines. The building or import of mines would neccestate a review of the submarine force to determine if the submarines are capable of carrying and deploying the respective mines. This capability might require the use of minebelts as discussed earlier, hence a determination must be made concerning potential for the mine to be deployed from a submarine torpedo tube or minebelt. The dimensions of the mines should be established to help determine the deployment limitations.

4. Countermeasures

Countermeasures are designed to thwart tracking of the submarine by hostile forces. The ability to employ countermeasures is a useful indicator of a submarine's capabilities. A submarine capable of using these deceptive devices will tend to be more able to avoid destruction in the event of being detected, drastically improving its survival. Due to the small size of countermeasures and the equally diminutive launching mechanisms, determining whether a submarine can use them may not be easy.

5. Surface-to-Air Missiles (SAMs)

The only mention of surface-to-air missiles on submarines have been with the SA-N-8 *Gremlin* mounted on a Russian *Kilo* class submarine while performing sea trials (*Jane's Fighting Ships, 1992-93*, p. 502). Other possible candidates could be the U.S.-produced *Stinger* or the U.K.-produced *Blowpipe*. These missiles usually have a range of three miles or less, but the possibility that a nation is fitting these to its submarines would be of interest in evaluating the threat presented by the submarine force.

C. SENSORS

The sensors in the submarine are sensitive units, especially when considering the hydrophones used for the sonar system. The processing systems can be changed by removing obsolete equipment cabinets and installing modern units.

> "Modern sonar equipments are based on modular components with a high proportion of functions that are performed by software, flexible adaptations to the user's wishes and requirements are possible especially with regard to the operation and displays .... For easy installation aboard existing submarines, the latest technology for high integration of electronics is used so that only one Operators's Console is necessary."(Pries, 1986, p.54)

This applies to the ESM gear as well as the sonar systems and periscopes. Sound analysis gear is readily available to be installed on submarines and can be connected to almost any type of hydrophones. The hydrophones themselves can also be replaced and improved with only minor modifications while the submarine is in a drydock.

A towed array allows a submarine to detect quieter ships at longer ranges compared to the normal hull-mounted arrays. The towed array sonar system has been the primary detection device utilized by U.S. submarines for many years, and even this sensor is becoming available worldwide with the *Moray 1800* submarine design which is offering a "clipped-on towed array sonar."("Submarine Design," 1990, p. 459).

D. NAVIGATION SYSTEMS

The navigation systems are probably the most easily installed units on the submarine. They are usually small and easy to operate; they should be evaluated based on their accuracy, maintainability and reliability. LORAN and OMEGA systems are readily available to any fishing vessel and, these combined with celestial navigation, are accurate enough to allow a submarine to navigate across any expanse of ocean. Most submarines are now equipped with some sort of ships inertial navigation system (SINS) which allows for submerged navigation with improvement over dead-reckoning, satellite and OMEGA navigation systems, and gyro compasses ("Combat Information," 1990, p.461). These units are also small; for instance, GEC Ferranti produces a submarine version of its inertial navigation systems which has two units (which measure 38 x 20 x 21 and 43 x 20 x 21 in.) and a mean time between failures (MTBF) of 4000 hours (GEC Ferranti, 1992, p.1). There are also Global Positioning System (GPS) receivers as small as a notebook which are becoming readily

available on the open market and which will allow accurate navigation in all but the most hazardous waters.

E. FIRE CONTROL SYSTEMS

The fire control system aids the submariners in determining a target's course, speed and range, calculates the course of the torpedo and sends this information to the torpedo. The system enables the crew to launch a torpedo with a reasonable chance of acheiving a hit. A good fire control system will provide a reliable firing solution in a relatively short period of time. The more sophisticated and modern systems will receive inputs from the sonar system and generate a firing solution without an input from the operators and the older systems require a substantial input from the crew. A good submarine crew can generate a firing solution without a fire control system, but manual methods are usual time-consuming. Although it should be emphasized that hand computations are quite capable of providing a firing solution to the submarine commander,

> Modern sub-surface warfare with its long ranges and short reaction times, its multiple contact situations and complex sensor and weapon resources requires combat systems at the leading edge of technology. (Pries, 1986, p.50)

This places a nation in the position of having to either provide extensive training to the crew to operate and maintain high-technology equipment or emphasize antiquated but well tested solutions. The choice a submarine force makes can provide an indication of the capabilities and

expertise of the submarine crews. In addition, the choice will also provide a hint as to the capabilities of the systems that are installed on the submarine.

VI. PERSONNEL

A. OFFICER LEADERSHIP

The naval leadership is an important factor in determining the effectiveness of a submarine force. The officer corps should be analyzed to determine their social status and education since these are important indicators of officer prestige.

1. Social Status

The stature of naval officers within a society and the social backgrounds of officers could influence the effectiveness of the submarine force. Where the officers come from within the social structure of the nation will affect their way of doing business or provide them added influence. Officers who come from elite segments of society tend to be more influential within the government, possibly giving the submarine force more leverage in the usually fierce infighting over resources.

2. Education

As with social status, a navy that requires officers to be highly educated would be predisposed to a more effective submarine force. Extensive education, while not an absolute necessity for a submarine officer, will tend to give the officer an advantage in technical skills, management, and problem solving, thus improving the prospects for becoming a

competent submariner commander. Note should be taken of the number of submarine officers which have attended higher learning institutions.

B. ENLISTED MANPOWER SOURCES

The education and social status of the enlisted submarine personnel should also be considered in evaluating a submarine force.

1. Education

The educational level of the enlisted men is as important to the operational competence of the submarine as the officers' education. The more knowledgeable the men are about their jobs and the missions of the submarine, the more effective the submarine is likely to be in its taskings. The literacy rate of the country will provide a quick indicator of the newly enlisted educational level, but a more precise sign might be the amount of training given the submariners after enlistment.

2. Social Background

While this aspect for the enlisted man is also similar to the officer discussion above, the evaluation can be done in broad perspective by looking at the percentage of population that is agrarian in nature. The higher the percentage the more likely the crew will be less capable, while a higher percentage of the population connected to seafaring or technical trades will probably be an indication of an effective force.

C. MORALE

The nebulous concept of morale needs to be reviewed when exploring the potential of a submarine force. There are many items that have effects on morale; while some of them are not easily determined, a few of the features described below can be readily determined and applied in assessment of a submarine force.

1. Esprit de Corps

There are many indications of the esprit de corps of the submarine force, from shoulder patches or distinctive uniforms to special privileges and an increased quality of life. The more obvious symbols of eliteness are easy to tally and the more distinguishing the symbols the higher probability that the morale of the submarine force is elevated. Some of the more obvious examples include qualification pins, shoulder patches, unusual uniform decorations, or even completely unique work or dress uniforms. Other less noticeable illustrations of esprit de corps are quality of life issues: preferable quarters, superior medical facilities, pay incentives, and even choice retirement benefits. Pay incentives are probably the most basic building blocks for improving morale. The amount a country pays its submariners relative to the rest of the navy and to the civilian pay scales can disclose much about the attitude of the nation toward the submarine force and the type of personnel who become submariners.

2. Officer-Enlisted Relationships

A major contributor to morale is the relationship between the officers and the enlisted men. A submarine is an environment unequalled in any civilian context if for no other reason than the extended time periods spent in small enclosed spaces. The attitudes of the officers pertaining to the enlisted men must be evaluated to aid in determining the capabilities of a submarine. A good working relationship is probably the most important non-material-related gauge of the effectiveness of a submarine. While it varies from vessel to vessel and even from time to time, the officer-enlisted relationship can be assessed generally for a force and sometimes for specific ships. Knowledge of that relationship is essential in determining a submarine force's capabilities.

3. Submarine Rescue

The knowledge that equipment is available and personnel are trained in submarine rescue can add to the morale of the submarine force. Because most conventional submarines operate primarily in shallow water areas, the possibility of rescue in an emergency could provide a morale boost to a submarine force.

VII. TRAINING

The training of the submarine crews and their maintenance personnel is extremely important to the effectiveness of a submarine force.

A. INTRODUCTION

Training a submarine force to fight is a difficult, time-consuming, and expensive task. Although basic navigational skills can be taught to a crew in a relatively short period of time, developing the crew to be effective warfare specialists operating as a team takes at least six years ("Creating A Submarine Force The French Way," 1989, p. 47). This allows time to fully train the captain and crew in the operational art of placing the submarine in an optimal firing position without being detected. With less training, a submarine can still be an effective "smart mine," but this may not seem worth the cost and resources that the country invests in a submarine force; it also would be an ineffective way to utilize a very capable warship. Submarine training must begin ashore with basic operational training, after which the training can progress to actual at-sea evolutions.

B. TRAINING ASHORE

Shore training must be looked at in both infrastructure and realization. Having the facilities is necessary but not sufficient for a submarine force to be proficient.

1. Training Infrastructure

The facilities that a nation devotes to submarine crew training provide an indication for determining a submarine force's ability to perform a given mission. Any review of shore training must include the types of facilities available to the crew. All aspects of submarine operations should be represented in the training structures -- diving trainers, weapons control and launching, fire control procedures, engineering operations, damage control trainers, and emergency escape training. The more elaborate are the training systems, the less time the crew needs to spend at sea to become proficient.

2. Training Realization

A review of the shore establishment should include the amount of time that a particular crew spends using the facilities. The initial stages of training can take place within the country or conducted in a foreign country for initial manning of new submarines. This training period does not need to be lengthy in nature, but it must encompass the theoretical aspects of submarine control and basic system operations. In the Federal German Navy, this initial operational training takes three months for enlisted personnel and six months for technical officers (Hartmann, 1986, pp. 108-109). Further shore-based training is customary after extensive refits or large changeouts of the crew. The training aspects discussed should not be

overlooked when trying to determine the missions and capabilities of a submarine force.

C. AT-SEA TRAINING

The at-sea training of the crews is of primary importance in evaluating the capabilities of a submarine. The most capable submarines in the world will be ineffective if the crews are not properly trained. Training at sea should be thoroughly examined to give the best perspective on the competence of the crew to perform a given mission. A submarine crew that has never been trained in ASW operations would probably be ineffective in executing that assignment. The types of operation that a submarine is capable of accomplishing are of such a varied nature that being trained in one mission does not indicate a capability in another mission. A submarine crew that is very good at performing commando insertion/extraction exercises or reconnaissance missions may not be a real threat against a formation of surface warships, while a crew which is very proficient at anti-surface warfare may have little success in locating and attacking a submerged submarine.

A detailed analysis of all training exercises should be accomplished to determine the nature of each exercise and the units involved. Lengthy independent steaming gives an indication of the proficiency of the crew in maintaining the ship without tender or shore support, which in turn implies an ability of the submarine to perform extended operational

patrols. Although some tasks can be performed with little or no training, the ability to conduct an extended patrol should not be assumed of any operational submarine. A submarine can conduct routine operations in shallow waters within sight of land; but the ability to deploy over a great distance takes practice and training and requires a high degree of confidence in both maintenance skills and navigational effectiveness. The French regularly send their diesel submarines on long patrols to the Indian Ocean for crew training in remote areas of the world's oceans (Fustier, 1989, pp. 32-36). Ships which often go in and out of port might be assessed as having a high degree of operational proficiency, but that submarine may not be able to conduct an extended wartime patrol.

Similar consideration should be given to snorkeling evolutions. A submarine which snorkels often might be exhibiting proficiency in operating at snorkel depth, but there are many other possible reasons, e.g., the submarine crew is demonstrating its inability to remain submerged on battery power, a reliance on external navigation, a requirement to maintain communications, or even a lack of confidence in the submarine's ability to return to the surface.

1. Training Missions

Every time a submarine goes to sea, every effort should be made to gather as much as information on its

operations as possible. All operations that are conducted must be analyzed to further aid in determining the capabilities of the submarine force. The U.S. axiom that a navy trains as it fights and fights as it trains is just as applicable to other submarine forces. The basic abilities of a submarine force will be evident during the operational exercises that are conducted. The frequency of noisy evolutions, the manner in which the submarine searches for an enemy, and the ability to maintain depth control are just a few of the examples which will tend to disclose the capabilities of a submarine force.

2. Routine Evolutions

This subject goes hand-in-hand with the concept of operations discussed later, but is more related to the tactical scale of operations. The submarine should be evaluated based on its ability to conduct routine evolutions safely, quietly, and effectively. These evolutions can be as simple as dumping trash to the more complex loading of weapons to the very critical evolution of coming to periscope depth. The evolutions need to be evaluated in three aspects: safety, stealth, and competence.

D. FOREIGN ADVISORS

The experience of foreign advisors tends to greatly benefit any training program. These advisors can range from non-participating observers to hands-on trainers to actual operators. The extent of the advisors' involvement will

probably relate to the competence of the crew. If a foreign country needs to supply actual operators, it is likely that the submariners in the host country are not proficient in submarine operations.

VIII. OPERATIONS

The types and frequency of submarine operations are indispensable in helping to determine the capabilities of a submarine force as are the causes and frequency of aborted operations.

A. OPERATIONAL ASPECTS

There is probably no better indication of the warfighting capabilities of a submarine force than the operations that it conducts in peacetime. Every aspect of operations needs to be examined in detail to ensure that all facets of submarine capabilities are explored.

1. Duration

The ability of a submarine to operate at-sea for an extended period of time is absolutely essential. The psychology of the crew and the durability of the equipment to perform lengthy patrols can only be tested by actually performing a sustained at-sea operating patrol.

2. Location

Where the submarines operate is also important. Submarines that deploy across vast expanses of ocean are probably the most capable submarines. To deploy long distances requires good navigational skills, confidence in the crew and equipment, high endurance platforms, and reliable communications. All of these capabilities were

common place among the major submarine powers in World War Two, but they cannot be matched by most nations that currently possess submarines.

3. Command and Control

The experience of World War Two has shown the world the importance of command, control, communications, and intelligence (C^3I) in relation to submarine operations. The German U-Boats were much more effective when used in coordination with other U-boats and when provided intelligence of convoy movements. This lesson should force us to keep a watchful eye on the ability of a shore-based naval component to communicate with and direct the operations of a submarine at-sea.

4. Participating Units

The operations that a submarine performs with other platforms should be analyzed to determine if the submarine is just acting as a target or if there is an actual combined operation taking place.

5. Types of Operations

Clearly, the emphasis placed on anti-surface warfare versus antisubmarine warfare needs to be reviewed to help determine the possible uses of submarines in times of conflict. An indication of proficiency in one aspect of submarine operations might be repetitive training in this area. A lack of apparent training in another area might be an indicator of inability to perform the mission. These are

not set in stone, because a submarine crew highly proficient in antisubmarine warfare is probably quite capable of conducting an anti-surface approach and attack, although the reverse may not be true.

B. FREQUENCY OF OPERATIONS

The types of operations that the submarines perform are important in the analysis, but a submarine that conducts one extensive operation every five years is not likely to be an effective platform. The operations must be conducted routinely to allow the crews to become proficient and ensure that the equipment is dependable. A comprehensive schedule should be made of each submarine's operational schedule to allow more thorough analysis of the capabilities of the submarine.

C. ABORTED MISSIONS

When a submarine must abort a mission, the reason for the cancellation must be determined. Given a thorough history of each submarine's operations, a good analyst can conduct a review of past terminations to reach an indication of the reliability and maintainability of the submarines. The reason for aborting a mission might be related to the lack of redundancy of onboard equipment or the inability of the submarine crew to repair the equipment at-sea.

IX. IRAN: A CASE STUDY

What has been presented above has been a theoritical mehtod for analyzing the capabilities and missions of a submarine force. This analysis method will now be applied to the newest submarine force: Iran's.

A. NATIONAL ASPECTS

Iran has undergone drastic leadership changes over the past thirteen years, but the geography and characteristics of the people have remained essentially stable.

1. Geography

Iran is a large country (636,296 square miles, about the size of California, Arizona, *New Mexico, and* Texas combined) that has a high interior region bounded by massive mountain ranges. The coastal areas are very narrow regions between the mountains and the shore. The surrounding seas are split by the Straits of Hormuz, and Iran has territorial sea perimeters of 900 km in the Arabian Gulf and 600 km in the Gulf of Oman.(*Encyclopedia Brittanica*, 1973, p.821)

The Arabian Gulf is fairly shallow throughout its entire length and the Gulf of Oman is also relatively shallow out to 75 or 100 kilometers, but after that the Gulf of Oman quickly changes into the Indian Ocean and deepens significantly. *This tomography* should require the Iranian navy to have a submarine force capable of blue-water

operations if anything more than a coastal defense role is envisioned.

2. Characteristics Of The Nation

The people of Iran are intensely religious, as was evident in the fundamentalist overthrow of the Shah in 1979. Their reliance on the army to protect the land borders from invasion is juxtaposed by their reliance on sea-based trade for their economic and social survival.

a. *Leadership And Status*

The leadership of Iran and its military starts at the Iranian Commander-in-Chief known as the *Faqhih* (The Supreme Jurist). This is the position created by Ayattolah Rouhollah Al-Moussavi Al-Khomeini and currently taken by Ayatollah Hojatolislam Khamenei. The *Faqhih* is also the country's spiritual leader. This is a very powerful position, especially when the man is a very charismatic leader like Khomeini, who was the Islamic Republic's founder and the revolution's spiritual leader. Since his death, the position has become weaker, mainly due to the offsetting power possessed by the President, Ali Akbar Hashemi Rafsanjani. Rafsanjani has moved rapidly to consolidate his power and has been very successful.(Malek, 1991, p. 1).

Rafsanjani has expressed a desire for Iran to become a major political, economic, and military power in the region and even in international circles. Although Iran has stressed that peace is its only goal throughout the region,

many nations are skeptical because Iran is still continuing to build the largest military force in the area of the Arabian Gulf and the Gulf of Oman. The Iranian response to these accusations is that its military must be made strong to ensure that the Islamic Republic can play a major role in the western Indian Ocean. The Iranian leaders have been quoted as saying that as "the strongest state in the region, Iran can better guarantee the security of the region."("JDW Interview," March 1991, P.304) This statement alone shows the importance that Iran places on their military strength, and indicates that Iran might probably use their military in a coercive manner to persue its interests in the area.

b. Characteristics of the Population

Despite their reliance on oil exports, the Iranian people are mainly agrarian in nature, with 33% of their population engaged in agriculture, 21% in manufacturing, and an unemployment rate of 30%. Iran has a shortage of skilled labor and is not self-sufficient in any economic area including food.(*World Factbook*, 1991, pp. 146-147)

The use of the sea is not foreign to Iran, but the large land borders have in the past given the Iranian people an easier way to trade. Recent population growth, poor relations with land neighbors, and the vast quantity of oil exported have shifted Iranian attention to the use of the sea in supporting its national interests.

c. *Role of the Navy*

During the Iran-Iraq War, the Iranian Navy proved its ability to contain the Iraqi Navy and was quite successful in taking the war to the enemy's homeland. Late in the war (1986), the Navy shifted units to the south that ended up in skirmishes with the U.S. Navy over the mining of the Persian Gulf and the Straits of Hormuz. The skirmishes with the U.S. Navy showed that the Iranian Navy was not as good as their early success against Iraq lead some observers to believe. The fighting caused the loss of one frigate and two fast patrol craft, with varying degrees of damage to other ships. Very little damage was inflicted on the U.S. Navy in return.(Cordesman, 1990, pp. 530-548)

The Navy in 1992 is the only portion of the Iranian military capable of going on the offensive, and it is continuing its buildup. As it grows, the Navy is remains centered around units from the Shah's navy. Due to the loss of several vessels in the Iran-Iraq War, ship acquisitions began during the war. An interesting view of naval priorities is shown by the types of ships which were acquired. Sixty-six naval units were procured during the course of the war: 8 amphibious ships and 8 support ships (1 replenishment ship); the rest were coastal patrol craft and small auxiliaries (*Jane's Fighting Ships, 1992-93*, pp.293-300). The patrol vessels were replacements for ships lost during the war, but Iran did not lose support or amphibious

ships. This suggests that Iran is developing a navy capable of sustained operations in a power projection role. In fact, the Iranian Chief of Naval Operations has stated that "his fleet plans 'to control the Strait of Hormuz' and to become a 'blue-water navy'" and that the *KILO* submarines are needed to help in "controlling the approaches to the Persian Gulf."(Sheafer, 1992)

d. *Size of the Submarine Force*

Iran is acquiring at least two *Kilo* Class submarines from Russia which would place it in the small submarine force category. This means that the submarines are likely to be used in one of four missions: coastal defense, special operations, mining, or commerce raiding. Iran's history of using mines would make this a viable mission, while its location at the Straits of Hormuz makes these submarines feasible platforms for the "intelligent mine" mission.

e. *Traditions*

The Iranian Navy has operated midget submarines for several years, but this is not likely to give them an edge in their utilization of a modern warfighting fleet submarine. The majority of the Iranian population probably did not know of the existence of these midget submarines, and their limited operational potential would not likely give them high standing within the naval hierarchy. Thus the Iranian submarine tradition is short and possibly nonexistent.

3. Overseas Interests

Iran relies on overseas trade for hard currency in the sale of its oil and to bring in food and materials to help build the economy.

a. *Distance and Trade Routes*

Most of Iran's exports are on ocean-going vessels to nations that are quite distant (Japan, Turkey, Italy, Netherlands, Spain, France, and Germany) and all of the oil must go through the Straits of Hormuz. The navy seems content with trying to monitor the northwest corner of the Indian Ocean, but as the navy acquires more ships the dream of sea control out to farther corners of the Indian Ocean will likely grow.

b. *Nature of Trade*

As mentioned earlier, 90% of Iran's exports is petroleum. Overseas trade is needed to bring in enough food supplies, machinery, and technical services to keep the economy going. Without the imports of food, Iran would probably suffer a famine. This implies that Iran must have a strong navy to insure that the needed food supplies can get into Iranian ports. Actually, strength at sea is a relative notion, since a major maritime power can impose an effective blockade.

c. *Foreign Relations*

Due to the leadership of President Rafsanjani, Iran reportedly is trying to establish relations with the

western world. Rafsanjani recognizes that Iran cannot develop in isolation, and the West, although looked upon as evil, is the best source of money and resources for helping to rebuild the war-shattered economy which is President Rafsanjani's number one concern (Malek, 1991, p.1).

Iran is also trying to develop ties outside the region based on the selling of arms produced indigenously. While their technology is not equal to the industrial countries, Iran cannot be independent of foreign controls unless their arms industry can support their military requirements. Economies of scale dictate that this is not economically feasible unless the Islamic Republic becomes an arms supplier. Major General Mohsen Rezai, Commander of the Iranian Revolutionary Guards Corps, is very proud of:

> our achievement of self-reliance in the field of weapon production, and our breakthrough in resolving complicated problems of electronics in weapons systems. In a few years, God willing, we will not only produce enough armaments to fulfil our needs but also to export. ("JDW Interview," November 1991, p.980)

This will place Iran in a very large group of arms exporters.

B. INDUSTRIAL AND TECHNOLOGICAL CAPABILITIES

Iran's modernization program was set back by the loss of the Shah's guidance, but after thirteen years, the industrial and technological capabilities of the nation are beginning to make a recovery.

1. Research and development

There is no evidence that Iran is attempting to explore the ocean areas in any way that would help their

submarine force. Iran's investment in research and development seems mostly centered around its arms industry. Money has been devoted recently to the co-development of Scuds with Syria which are capable of carrying chemical warheads (Haberman, 1992, p.3).

2. Indigenous Production And Imports

Iran is not yet producing the *Kilo* submarines; but they do have the infrastructure, dockyard facilities, and experience (gained from repairing crippled ships during the Iran-Iraq War) which have led one writer to suggest that "Iran will, if so desired, have no trouble in building her own hulls."(Slade, 1991, p.32) Iran is unable to manufacture the sensors and weapons systems which are needed to equip a modern naval platform, therefore these systems will have to be acquired from overseas (Slade, 1991, p.32). Iran, like many other developing nations, does have the ability to reverse engineer equipment to some extent and this could be the source of spare parts for their submarines.

3. Maintenance And Repair

Iran has ship repair facilities at only Bandar Abbas. Iranians have the capability to repair naval warships, as they proved by almost totally rebuilding the frigate *Sabalan* after having "her back broken by three *Harpoon* missiles and five laser-guided Rockeye cluster bombs."(Slade, 1991, p.32) The major repair facility is the Persian Gulf Shipbuilding Corporation in Bandar Abbas which has the capability to

repair vessels up to 28,000 tons (*Fairplay World Shipping Directory, 1992-1993*, p.285). This is the only facility in the country that can repair submarines. Notice should be taken of any expansion of this facility or the building of any future repair facilities. Where the Iranian Navy will send its submarines for major overhauls is not known.

4. Specialized Industries

Iran does not presently have the specialized industrial capabilities required to maintain their submarines, so Iran will be dependent on foreign suppliers for these skills and parts.

C. INFRASTRUCTURE

1. Submarine Bases

Iran does not yet have a submarine base, but *Jane's Fighting Ships, 1991-92* (p.286) states that a submarine base is being built at Chah Bahar on the Gulf of Oman, some 70 miles west of Pakistan and 250 miles east of the Straits of Hormuz. With only two submarines being delivered it can be assumed that there will only be one submarine base for some time to come. The submarines will likely be based in Bandar Abbas until the submarine base is completed. A determination should be made as to the amount of pier space which is being built at Chah Bahar to help aid in the analysis of the projected size of the submarine force. Due to the limited nature of the Iranian Navy, submarine tenders are not seen as necessary, but any discussion of acquiring a tender would

imply a major shift in Iranian intentions. Also, an estimate must be made of the potential for building drydocks, and the quantity and quality of the training facilities must be monitored.

D. EQUIPMENT

1. Submarine

The *Kilo* submarine is the newest conventional submarine produced by Russia and it is designed for ocean-going operations. It is a large submarine and, at 3076 tons submerged displacement, is large even by diesel submarine standards. This size makes it a very poor shallow water submarine, but many nations are acquiring *Kilo* submarines due to their relatively cheap price tag. "The Iranians are reported to have paid $2.1m [U.S. dollars] for each of their three 'Kilo' submarines," about 1 per cent of a Western submarine."(Preston, 1992, p.15) The modern technology involved in the *Kilo* submarine makes it a formidable platform. The maintenance requirements should be comparatively routine for the near future, although poor upkeep will probably cause the submarines to deteriorate rapidly.

a. *Capabilities*

While many aspects of the *Kilo* submarine are unknown, the data available in *Jane's Fighting Ships, 1992-93* (p. 294) is enough to begin an analysis of the Iranian submarine force capabilities. The patrol endurance of the

Kilo is about 50 days based on nominal fuel consumption and consumable loadouts, although this number can be increased by conserving fuel and storing extra food and supplies. The submerged endurance is quoted as 400 nautical miles at 3 knots which would allow the *Kilo* to be submerged for over five days while patrolling a strait or coastal area. This range will allow the *Kilo* to transit to the Straits of Hormuz while remaining submerged, but the *Kilo* will not be able to return to Chah Bahar submerged. The cruising range of the *Kilo* (6000 nm at 7 kts) will allow the Iranian submarine force to patrol the entire Arabian Sea, most of the Red Sea, and a major portion of the western Indian Ocean. *Jane's* lists the submerged speed as 17 kts, but the equations presented above give a speed of 23 kts. This is a more realistic speed based on the size of the *Kilo* and its large propulsion motor.

b. Missions

The *Kilo* submarine was designed by the former Soviet Union as a multi-purpose platform to replace its aging fleet of diesel submarines and has all but replaced earlier classes. For this reason the *Kilo* is likely to be very suitable for all missions that can be assigned a diesel submarine, with the possible exception of strike warfare. The Shark Teeth sonar system is a very capable system for ASW and ASUW, and if armed with Russian Type 53 torpedoes, the *Kilo* can not only detect ships but sink them as well. The

Kilo can deploy mines from its torpedo tubes and has the interior room for conducting special operations. The capability to launch missiles is not credited to the *Kilo*, but with the proliferation of *Harpoon* and *Exocet* missiles, and the ability to retrofit a submarine with the required control equipment, this capability must be assumed of any modern submarine. *Jane's Fighting Ships, 1992-93* also specualtes about the possible installation of a surface-to-air missile system on some *Kilo* submarines. This should be investigated further after the delivery of the submarines. The normal torpedo loadout is 18 *Type 53* or two mines in place of one torpedo. These weapons must be impulse launched which gives the *Kilo* operational flexibility in depth and speed while engaging targets.(*Jane's Fighting Ships, 1992-993*, p.268 & 294)

2. Weapons Systems

As mentioned above, the Type 53 Russian torpedo is the likely weapon of choice, although any number of available torpedoes can be utilized by the *Kilo* after modification. No missiles will be deployed until some modification is given to the submarine also. Iran has employed mines for many purposes in the past, and in any future conflict or crisis, the reappearance of Iranian mines in the Arabian Gulf, the Straits of Hormuz, or the Gulf of Oman should not be totally unexpected. An analysis of the Iran-Iraq War shows that a major strategic concept for Iran is the willingness to

escalate war rapidly from a strictly military land conflict to a total war including naval combat, ballistic missile strikes against civilian populations, attacks on neutral shipping, with missiles and indiscriminate mining of international waterways (Barbero, 1989, pp.25-26). Russian countermeasures will likely be supplied with the submarines, and if a SAM launcher is installed, SA-N-8 *Gremlin* will probably be the missiles used.

3. Sensor/Navigation/Fire Control systems

The Shark Teeth medium-frequency detection and tracking sonar system and the Mouse Roar high-frequency attack sonar are standard equipment for the *Kilo* submarine. These sonar systems have proven to be reliable in service with the ex-Soviet Navy, so their reliability and maintainability should not be in doubt. The navigation systems will probably include Loran and Omega units with the possibility of a satellite navigation receiver. With the availability of GPS receivers, this is a likely device to be installed, although Iran may not have facilities to repair any of the mentioned electronic equipment.

E. PERSONNEL

The Iranian military went through major changes during the revolution and in the long conflict with Iraq.

1. Officer Leadership

Of the 55,000 officers in the Shah's military, over 12,000 officers were purged, either by execution or by forced

retirement. Most of the purged officers were from the Army, while very few were Navy.(Zabh, pp.118-123) This gave Iran a good foundation for building a wartime navy and these men who developed strategic concepts in defeat and in victory which are likely to govern future Iranian military actions. As for the educational level of the officer corps, there are eighteen universities that have technical or engineering departments with about 125,000 students, and another ninety colleges and technological institutions that can possibly offer the navy a selection of highly trained and competent individuals (*World of Learning 1992*, pp. 724-729). In addition there is a maritime school, the Chah Bahar College of Nautical Studies, for the teaching of various seagoing-related courses (*Fairplay World Shipping Directory, 1992-1993*, p.666).

2. Enlisted Manpower Sources

This subject must be approached from a broad perspective when looking through the literature. As mentioned earlier, Iran is an agrarian nation which can make it difficult to find the manpower needed to operate modern complex warships. Its literacy rate is only 54% and there are two major languages spoken (Persian and Turkic) among it 15 million work force (*World Factbook*, 1991, p. 146). The ability to take men unacquainted with the ways of the sea and teach them naval matters and submarine systems is a long and complex process which can take many years. This alone should

give an indication that the quality of the Iranian submarines will not be prominent for at least several years.

3. Morale

The esprit de corps of the submarine force will likely be limited at first due to a lack of history. As the force becomes better trained and more experienced, it is likely to develop an eliteness like most other submarine forces. The officers will probably form a closer bond to the enlisted personnel due to the extremely cramped conditions inherent in the submerged environment. And the esprit de corps could probably be strengthened if a form of rescue from a stranded submerged submarine is provided as an integral part of the submarine force. All of these factors will probably influence morale and should be carefully considered when determining the missions and capabilities of the submarine force.

F. TRAINING

Since the submarines have yet to arrive, no real analysis can be performed on the training environment of the submarine force. As discussed, the training facilities which are being erected at Chah Bahar, the training facilities used by other parts of the navy, and the utilization of those training systems, should be studied. An examination of the Iranian surface navy will also give a suggestion of the types, complexity, and thoroughness of their training. This can then be extrapolated to the future at-sea training

environment of the submarine force. The quantity of foreign advisors will probably decrease in number as the submarine force becomes more proficient at operations, and this might give a good indication of the operational readiness of the Iranian crews to perform actual missions.

G. OPERATIONS

As with training, the operations that the submarine force performs can only be inferred from the current operations performed by the surface navy. All the items discussed above should be carefully reviewed after the Iranians take possession of the *Kilo* submarines.

H. CONCLUSIONS

Using locally available unclassified resources and the method articulated in this study, some inferences may be drawn about the future capabilities of the Iranian submarine force.

Firstly, the *Kilo* submarine is a highly capable platform that should be able to fulfill any assigned missions. It is a blue-water submarine with a range that could allow the Iranian navy to influence events several thousand miles from the Arabian Gulf.

The second inference that can be drawn is that the capabilities of the Iranian crews will be limited for several years due to inexperience in submarine operations. After a short period of training, the submarines will likely be capable of performing only restricted independent operations

close to their base with a possibility of executing an "intelligent mine" mission in the Straits of Hormuz and the Gulf of Oman. The submarine force will probably be many years from becoming an integrated member of a navy task group.

The last prediction is that Iran, possessing submarines will likely use them in any future conflict to achieve their goals. Whether against hostile naval or merchant vessels or even neutral shipping, the Iranian submarine force will be directed to use the destructive weapons at their disposal.

However it should be noted that these conclusions are drawn from locally available sources and limited research. Applying this method with more complete and current information and tapping classified resources for an all-source analysis should yield a much more reliable appraisal of the future Iranian submarine force missions and capabilities.

X. SUMMARY

The method presented in this thesis for evaluating the missions and capabilities of a Third World submarine force is meant to provide an informed reader with the basic building blocks to begin an analysis. It should be stressed that a sufficient application of the method would compel the use of highly classified intelligence data, specific and thorough open-source research information, and special collection tasking of attaches, ships, submarines, aircraft, and other collection methods. It is desired that this unclassified, limited open-source assessment model for evaluating a submarine force will encourage an all-source application on all potentially hostile submarine forces.

APPENDIX: CHECKLIST FOR EVALUATION

GEOGRAPHY (i.e. island or sea-based nation, length of territorial seas, and depth and extent of surrounding waters)

CHARACTERISTICS OF THE NATION (i.e. leadership views, world status, population characteristics, the navy's role, size of the submarine force, and naval traditions)

OVERSEAS INTERESTS (i.e. distance and routes of sea-based trade, nature of sea trade, and foreign relations)

INDUSTRIAL AND TECHNOLOGICAL CAPABILITIES

RESEARCH AND DEVELOPMENT (i.e. oceanographic and weapons)

INDIGENOUS PRODUCTION AND IMPORTS (i.e. submarines, spare parts, and weapons)

MAINTENANCE AND REPAIR (i.e. number of facilities, location of overhauls or routine maintenance, duration, and quality)

SPECIALIZED INDUSTRIES (i.e. technical development and production in the fields of optics, welding, electronics, batteries, advanced technologies, and sound silencing technologies)

INFRASTRUCTURE

SUBMARINE BASES (i.e. number of bases and pier space, tenders, drydocks, and training facilities)

EQUIPMENT (i.e. age, complexity, and maintainability of the submarine's sensors, navigation systems, and fire control systems)

SUBMARINES (i.e. size, age, technology, number for a given mission, weapon storage, weapons launching systems, and surface-to-air missile (sam) launchers)

CAPABILITIES (i.e. patrol endurance, submerged endurance, range, open-ocean potential, and speed)

MISSIONS POSSIBILITIES (i.e. ASW, ASUW, special operations, mining, surveillance, reconnaissance, electronic warfare, strike, and search and rescue)

WEAPONS SYSTEMS (i.e. size, technology, and effectiveness of torpedoes, missiles, mines, countermeasures, and surface-to-air missiles)

PERSONNEL (i.e officer social status and education, enlisted manpower education and social background, esprit de corps, officer-enlisted relationships, and submarine rescue)

TRAINING

TRAINING ASHORE (i.e. training infrastructure and training realization)

AT-SEA TRAINING (i.e. training missions and routine evolutions)

FOREIGN ADVISORS (i.e. number and purpose)

SUBMARINE OPERATIONS (i.e. duration, location, C^3I, participating units, types of operations, frequency of operations, and frequency and causes of aborted missions)

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